

TECHNICAL REPORT

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**Carbohydrate-Electrolyte Solution During Military Training: Effects
on Physical Performance, Mood State and Immune Function**

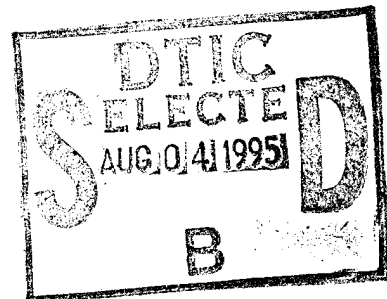
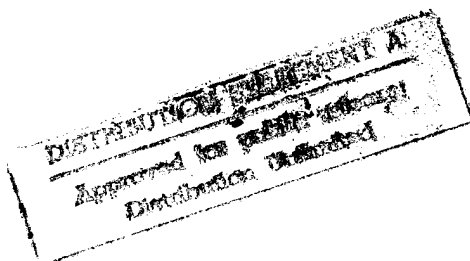
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| 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited. | | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) This study determined the effect of carbohydrate-electrolyte (CHO-E) beverages during several days of military field training on performance of military tasks and immune cell responses. Twenty-seven volunteers restricted to ~2600 kcal·day ⁻¹ were randomly assigned to one of three groups: CHO-E beverage, placebo, or water. Fluid intake for all groups was <i>ad libitum</i> . The volunteers completed 3 days of physically demanding field training in hot humid conditions (30°C, 60% rh). Field training days 1 and 2 each included a 16-21 km march over hilly terrain, marksmanship training, and 2 h of rock climbing. Field training day 3, included a 14.5 km march followed by marksmanship tests, a timed rock climb and a 1.3 km uphill (21% grade) run. The CHO-E beverage provided an additional ~2800 kcal (P<0.05) for the 3 days of training. There were no differences (ANOVA, P<0.05) between the groups' absolute or changes from pre-training values for fluid intake, body weight, climb time, run time, marksmanship, or mood. Those drinking CHO-E were, however, more likely to maintain uphill run performance after training (Chi square = 7.2; P<0.05) and more likely to maintain both uphill run and marksmanship ability (Chi square = 17.2; P<0.05). There was also an inverse relationship between caloric intake and deterioration of uphill run performance (r=-0.75; P<0.05). CHO-E resulted in less increase (P<0.05) in white blood cells and granulocytes after the day 3 circuit. There was, however, no difference in lymphocyte proliferation response between CHO-E and water before, during, or after field training. It was concluded that: 1) CHO-E beverages can increase caloric intake during field training; 2) persons drinking CHO-E or practicing good food discipline are more likely to sustain physical performance than those who eat only a portion of their food; and 3) CHO-E provide an accessible source of calories which can be advantageous when limited food is available or inadequate food consumption is likely. | | | | |
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LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|-------|----------------------------------|
| ADI | Acceptable daily intake |
| CHO | Carbohydrate |
| CHO-E | Carbohydrate-electrolyte |
| DCM | Distance from centroid of mass |
| DEXA | Dual-Energy X-ray Absorptiometry |
| Hb | Hemoglobin |
| Hct | Hematocrit |
| MRE | Meal, ready-to-eat |
| POMS | Profile of mood states |
| RI | Ranger instructor |
| SFAS | Special Forces Assessment School |
| SGT | Shot group tightness |
| STIME | Sighting time |
| WBGT | Wet bulb global temperature |

EXECUTIVE SUMMARY

Carbohydrate-electrolyte (CHO-E) beverages have been shown to improve an athlete's ability to perform endurance exercise. The purpose of this study was to determine whether CHO-E beverages improve mood state and performance of military tasks. A second purpose was to examine if CHO-E solutions alter immune cell responses. Twenty seven volunteers were recruited from the ranger cadre, 5th Ranger Training Battalion, Camp Merrill, GA. Volunteers were randomly assigned to one of three groups. One group drank a CHO-E beverage containing 20 mEq·L⁻¹ NaCl, 2.5 mEq·L⁻¹ K⁺, and 70 g·L⁻¹ carbohydrate, 280 mOsm·L⁻¹. A second group drank a colored, flavored, non-caloric (Aspartame) placebo. A third group drank water. Fluid intake for all groups was *ad libitum*; food intake was restricted to ~2600 kcal·day⁻¹. Subjects completed 2 days of field training in warm (30°C), humid (60%rh) conditions. Each day included a 14.5-21 km march over hilly terrain, marksmanship training, and 2 h of rock climbing. On day 3, a circuit was completed consisting of a 14.5 km march, marksmanship, timed rock climb, and 1.3 km timed uphill (21% grade) foot race. Perceived mood was similar among the groups throughout the study. There were no differences ($P < 0.05$) between the three groups for either absolute values or changes from pre-training values for fluid intake, body weight, climb time, run time or marksmanship ability. There was a trend for foot race time to be better preserved in the CHO-E group. Preservation of foot race time, however, was inversely related to the carbohydrate and caloric intake of the placebo and water groups ($r = -0.75$ and $r = -0.78$, respectively). Immune cell responses to field training were affected by beverage composition. CHO-E resulted in less increase ($P < 0.05$) in white blood cells and granulocytes after the day 3 circuit. There was, however, no difference in lymphocyte proliferation response between CHO-E and water before, during, or after field training. It was concluded that drinking CHO-E beverages during 3 days of military training does not improve physical performance of military tasks.

INTRODUCTION

Soldiers performing military field training or their war-time mission generally drink insufficient fluid to maintain euhydration and ingest insufficient calories to maintain caloric balance (Armstrong, 1994; Draper and Lombardi, 1986; Jones et al., 1990; Leithead and Pallister, 1960; Roberts et al., 1987; Strydom et al., 1968). Dehydration is known to elevate core temperature, increase the risk for heat casualties, and reduce physical performance (Adolph et al., 1947; Pitts et al., 1944; Ladell, 1955; Bean and Eichna, 1943; Eichna et al., 1945; Montain et al., 1992; Strydom et al., 1968). Decreased body water as a consequence of sweating reduces endurance time (Pitts et al., 1944; Ladell, 1955; Bean and Eichna, 1943), tolerance to heat strain (Sawka et al., 1992) and reduces marksmanship (Strydom et al., 1968; Tharion et al., 1989). Furthermore, for soldiers in the field, the daily caloric intake is often only 2600 to 3000 kcal despite expending greater than 3600 kcal daily (Jones et al., 1990; Roberts et al., 1987). This caloric deficit can reduce endogenous carbohydrate content, which is known to reduce endurance exercise performance (Christensen and Hanson, 1939; Hultman, 1967; Gollnick et al., 1981). Therefore, it is important for the military to develop strategies to improve both fluid and caloric intake of soldiers performing their military mission.

Providing a carbohydrate-electrolyte beverage rather than water as the primary fluid replacement beverage during field operations in a hot environment may reduce the magnitude of dehydration-mediated heat strain and may improve military performance. During exercise-heat stress, persons will voluntarily ingest a larger volume of a sweetened flavored beverage than water (Hubbard et al., 1984; Sohar et al., 1962; Rose et al., 1989). In addition, less urine is excreted following ingestion of a carbohydrate electrolyte solution compared to drinking an equal volume of water (González-Alonzo et al., 1992; Nose et al., 1988). As soldiers typically ingest ~2700 kcal per day despite expending >3600 kcal per day while in the field (Jones et al., 1990; Roberts et al., 1987), dietary supplementation with a carbohydrate-electrolyte solution may reduce the caloric deficit accrued during field operations. Ingestion of 5 L of a 5% carbohydrate solution would potentially add an additional 250 g of carbohydrate or 1000 kcal to the daily dietary intake.

Several laboratory investigations have demonstrated that exercise performance is improved when endurance trained athletes ingest carbohydrate-electrolyte beverages rather than water during prolonged, moderately intense exercise (60-75% maximal oxygen consumption)(Coggan and Coyle, 1991). Athletes consuming carbohydrate-electrolyte beverages, compared to a placebo solution, are able to exercise longer before fatiguing (Coggan and Coyle, 1991; Wright et al., 1991) and are able to maintain a higher power output during the latter stages of exercise (Williams et al., 1990; Mitchell et al., 1989; Neufer et al., 1987; Wright et al., 1991). Furthermore, when athletes consume carbohydrate both before and during moderately intense exercise, they can exercise longer before reaching exhaustion and maintain a higher power output late in exercise compared to if they only consume carbohydrate during exercise (Wright et al., 1991). Carbohydrate supplementation appears to augment performance by providing an exogenous source of carbohydrate when liver and muscle glycogen can no longer provide the glucose required to maintain the required power output (Coyle et al., 1986; Hargreaves and Briggs, 1988).

It is unclear, however, whether soldiers would benefit from carbohydrate supplementation during military tasks. Studies which reported improved endurance exercise performance for athletes ingesting carbohydrate during exercise were performed after the subjects fasted overnight, when the exercise intensity required a relatively high rate of carbohydrate oxidation (approx. 2 g min^{-1}), and when the exercise duration was 2 to 4 h. Military exercise tasks, in contrast, are not generally performed after an overnight fast, are at an exercise intensity which does not require a high rate of carbohydrate oxidation, are less dependent on endogenous carbohydrate as a metabolic substrate, and may be much longer in duration. Since soldiers consume 300 to 400 g of carbohydrate daily, further carbohydrate intake may not be necessary to maintain normal liver and muscle glycogen concentrations. Studies which have compared the effects of caloric (and carbohydrate) restriction to a control diet during field operations have reported no difference in exercise performance, marksmanship, or cognitive performance between groups (Crowdy et al., 1971; Crowdy et al., 1982; Consolazio et al., 1979). However, in the studies of Crowdy et al. (1971, 1982) and Consolazio (1979), preservation of exercise performance was directly related to caloric intake, suggesting that the detrimental effects of caloric restriction may have been masked by other factors (e.g., improvements in physical fitness, acclimation, learning or

practice, insensitive dependent indices of performance, and insufficient statistical power). Because of the prohibitive expense of including a carbohydrate-electrolyte beverage in military food rations, it has not been added to the military feeding system. The DoD Food and Nutrition Research, Development, Test, Evaluation, and Engineering Program has been tasked with evaluating whether carbohydrate-electrolyte beverages enhance military performance.

To date, few studies have compared the effects of carbohydrate-electrolyte solutions to water alone during military related tasks. Levine et al. (1991) examined if CHO-E beverages improve performance of soldiers performing 24 h of intermittent marching in a hot climate. They found no difference in endurance time, body temperature, or blood chemistries when soldiers ingested either a carbohydrate-electrolyte beverage or water during exercise. The subjects in this investigation, however, were encouraged to ingest fluids and the magnitude of dehydration was similar between groups throughout exercise. Burstein et al. compared *ad libitum* fluid intake of water or CHO-E by soldiers performing ~30 km road marches for 4 consecutive days. They reported no difference in fluid intake between beverages but soldiers drinking CHO-E had higher plasma glucose concentrations compared to those drinking water. Rose et al. (1989) examined the *ad libitum* consumption and acceptability of two colored, flavored CHO-E solutions compared to water during 8 days of field operations. They reported that volunteers drank more when provided flavored fluids rather than water. They did not assess whether the larger volume of fluid intake attenuated hyperthermia or improved exercise performance.

Two recent studies (Diaz et al., 1991; Sherman et al., 1993), using non-military personnel, examined whether carbohydrate and caloric supplementation, or caloric supplementation alone would improve physical performance of occupational tasks. Despite better maintenance of skeletal muscle glycogen concentration (Sherman et al., 1993) and body weight (Diaz et al., 1991), neither study found that supplementation improved endurance performance.

The primary purpose of this investigation was to determine whether ingestion of a glucose-electrolyte solution during several days of military field training, under caloric restriction simulating a realistic caloric deficit, improved endurance exercise

performance, marksmanship, and mood perception compared to ingestion of water and a sweetened, non-caloric, non-electrolyte placebo solution when all fluid replacement solutions were provided *ad libitum*. The field training consisted of prolonged strenuous road marching, rock climbing, and marksmanship training. The soldiers were provided a limited supply of food to eat (~2600 kcal/day) and a caloric deficit accrued during the study. The objective was to induce a realistic cumulative caloric deficit and to create a situation where large volumes of fluid intake would be required each day to maintain hydration, thereby increasing the likelihood of observing differences in our dependent measures with the experimental treatment.

A secondary purpose of this investigation was to determine whether ingestion of a carbohydrate-electrolyte solution rather than water during training alters immune cell concentration and responsiveness. In most sustained conflicts, more casualties are lost due to infection than from enemy fire. Therefore, there is great interest in reducing infection and disease. In a recent study, Moore et al. (1992) examined the effects of high energy expenditure, hypocaloric intake, and sleep deprivation during US Army Ranger training on cellular immune function and systemic cytokine production. They found that Ranger training resulted in suppression of mitogen induced T-lymphocyte proliferation and suppressed systemic production of interleukin-6. Shippee et al. (1995) demonstrated that a 16% increase in total calories attenuated immune suppression during Ranger Training. This study examined whether dietary modification with a CHO-E beverage altered immune responses over several days of strenuous training.

METHODS

EXPERIMENTAL APPROACH

The study was conducted at Camp Merrill, Dahlonega, Georgia and Mount Yonah in Chattahoochee National Forest, Georgia. Both areas are located in the mountains of the Tennessee Valley Divide. The study spanned 6 days: 2 days of baseline measurements, 3 days of exercise training and performance testing, and 1 day of end measurements. The test subjects were randomly divided into 3 experimental groups: *ad libitum* intake of a carbohydrate electrolyte solution (20 mEq·L⁻¹ NaCl, 2.5 mEq·L⁻¹ K⁺, and 70 g·L⁻¹ carbohydrate, 280 mOsm·L⁻¹), *ad libitum* intake of tap water,

and *ad libitum* intake of a colored, non-caloric sweetened (Aspartame) solution which contained no electrolytes (Placebo). The CHO-E beverage and the placebo solution were developed using the same lemonade flavor base, giving them the same color and flavor. The composition of the CHO-E beverage was consistent with that recommended by the National Academy of Sciences for a military replacement beverage (Food and Nutrition Board, 1994). The subjects began *ad libitum* fluid intake of their experimental beverage with the onset of field training on day 3 and continued *ad libitum* intake until day 5 testing was completed.

During exercise training, it was anticipated that the soldiers would expend approximately 4000 kcal and lose 4-6 L of water through sweating per day. Each soldier was given 2 MREs per day (~2,600 kcal); no other food was permitted. They slept in the field the evening of day 2 through day 4. The final day of field training, or day 5 of the experiment, contained four experimental tests to evaluate whether the composition of the fluid replacement solution enhanced soldier performance and mood perception. In addition, a blood sample was collected to examine immune function.

Exercise performance was examined using a timed foot race and timed rock climb. Marksmanship was evaluated using the Noptel ST-1000 weapon simulator system. Mood state was examined using the Profile of Mood State (POMS) Questionnaire. Day 5 testing was performed as a circuit consisting of (in order): marksmanship, POMS, road march with full rucksack, marksmanship, rock climb, foot race, marksmanship, POMS and blood draw. On day 6, changes in body composition and body water volume were evaluated, along with a final blood draw.

SUBJECTS AND TREATMENT ASSIGNMENT

Twenty-eight male infantry soldiers from the 5th Ranger Battalion Ranger Instructor (RI) Cadre were recruited for the study. All of the soldiers were healthy, experienced rock climbers, and were familiar with the M16A2 rifle. In addition, they regularly trained in the geographic region used for testing. The volunteers were randomly assigned to 9 three-man teams with each team member receiving one of the three experimental beverages. Therefore, there were nine soldiers receiving each drink solution, and any influence of time of day of testing (i.e. weather, circadian rhythm, etc.)

was balanced across the treatment groups. The extra volunteer was assigned to the CHO-E group. The physical characteristics of the three treatment groups are presented in Table 1.

EXPERIMENTAL DESIGN

Table 1. Subject Characteristics.

| | CHO-E | Placebo | Water |
|------------------------------------|----------|----------|-----------|
| Age, yr | 30±5 | 28±5 | 30±4 |
| Height, cm | 174±7 | 173±4 | 175±8 |
| Weight, kg | 77.2±8.1 | 81.5±7.0 | 79.5±11.3 |
| Body Fat, % | 16±3 | 18±4 | 17±4 |
| Total Body Water, L | 44.8±5.0 | 45.0±5.0 | 46.1±4.7 |
| Total Body Water, % of Body Weight | 58±2 | 55±4 | 58±3 |

Data are means±sd for 10, 7, and 10 subjects in CHO-E, Placebo and Water groups, respectively, except for total body water which is from 9, 7, and 9 subjects.

Preliminary testing was performed on day 1 and 2 of the study. Preliminary tests included: a morning venous blood sample (24 ml) drawn after an overnight fast for determination of baseline nutrition, immune and health status; determination of total body water volume using the deuterium oxide and bioelectrical impedance

methods; assessment of body composition using Dual-Energy X-ray Absorptiometry (DEXA); two timed climbs up the pre-determined rock climb course and a timed foot race. In addition, the soldiers completed four practice sessions using the Noptel weapon system, and received instruction for completing the POMS and dietary log forms. The blood sample was obtained on day 1. To complete the other preliminary tests, the soldiers were divided into two groups. On day 1, one group completed the total body water and body composition procedures, while the other group completed the rock climb and foot race tests. On day 2, the two groups were reversed. During each day, the soldiers practiced the marksmanship test on two separate occasions; thus, practicing on four separate occasions during the 2-day preliminary testing period. On the evening of day 2, all soldiers were transported to the basecamp at Mount Yonah. They remained camped at Mount Yonah until day 5 testing was complete. The intent was to have the soldiers live continuously in a hot climate during the training period.

Military relevant training and testing were performed on days 3 to 5 of the study. On the morning of day 3, the subjects awoke, voided their bladders, and baseline body

weights were measured. After a light breakfast, each three-man team then completed POMS and baseline marksmanship testing before initiating a 21.5 km march on paved and dirt roads. The course was hilly, with a 350 m ascent over the final 3.9 km of the course. After a break for lunch and rest, they completed 2 h of rock climbing (both free climb and rope assisted methods) and marksmanship training.

On day 4, the subjects performed the same procedures and training as on day 3, with the exception that there were no POMS or marksmanship testing prior to the road march. In addition, at the Medical Monitor's request, the road march course was shortened from 21.5 km to ~16.5 km to eliminate the final 3.8 km uphill portion of the march and to avoid automobile traffic on the first 6 km of the course. This was requested because of the number of individuals seeking medical attention for heat related-illness (n=6) after the day 3 march and to reduce risk of physical injury.

On day 5, the subjects awoke, voided their bladders and had their body weights measured. POMS and marksmanship testing were then completed. At 20 min intervals, each team then began an exercise circuit which included (in chronological order): a 14.5 km road march with rucksack (the shortened day 3 course and no rucksack on the final 3.8 km uphill portion of the march), marksmanship testing, POMS questionnaire, rock climb, timed foot race, body weight measurement, marksmanship testing, and POMS questionnaire. During the road march with pack, the teams were instructed to complete the course as a team and to walk at a "specified" pace through each checkpoint. In this way, the distance between teams remained evenly spaced. After completing the circuit, a 24 ml venous blood sample was drawn.

Endpoint measurements were performed at Camp Merrill on day 6 of the study. Endpoint measurements and samples were: body weight, body composition, final 24 h urine, total body water, and a 24 ml venous blood sample.

EXPERIMENTAL PROCEDURES

Climatic Conditions

The dry bulb, wet bulb, WBGT, and wind speed were measured at periodic intervals during each day of experimental testing at the basecamp and on the road march course. Dry bulb and wet bulb temperature were obtained using a sling psychrometer. WBGT was measured with a heat stress monitor (Wibget, Reuter Stokes). Wind Speed was measured with a floating ball-type anemometer.

Foot Race

The foot race was performed on the dirt path linking the base of the rock climbing course to the basecamp. It began at the base of the rock climb course and ended at the basecamp. The 700 m course was uphill with an elevation gain of 150 m from beginning to end (or an average grade of 21%). The soldiers were instructed to run or walk the course as rapidly as possible while being timed. The foot race was performed without rucksack.

Rock Climb

The rock climb was performed on a climbing lane on a cliff at Mount Yonah. The direct-aid climbing technique was used (TC 90-6-1). The rock climb began at a specified starting line with necessary climbing gear attached to the soldier. The climb ended when the soldier reached the top of the climbing lane and cleared all climbing equipment from the lane. During baseline testing, the soldiers climbed the course as rapidly as possible two times separated by a minimum of 20 min rest. The fastest time obtained for each subject was used for their baseline climb time. On day 5, the subjects climbed the lane only once.

Marksmanship Assessment

Marksmanship was quantified with a laser marksmanship simulator (Noptel ST-1000; Oulu, Finland) attached to a disabled M16A2 rifle. Marksmanship parameters assessed were: distance from centroid of mass (DCM), shot group tightness (SGT), and sighting time (STIME). DCM, SGT, and STIME were calculated using previously established procedures (Tharion et al., 1992). The simulator consisted of a laser transmitter, an optical target, a personal computer, a printer, Noptel software, and a

disabled M16A2 rifle. The laser transmitter emitted an invisible continuous 0.55 mm, 0.8 μ m wavelength beam that allowed aiming positions to be monitored and recorded throughout the sighting and shooting process. A vibration sensor in the laser transmitter detected when the weapon was dry-fired. Shot location of the laser was recorded from the laser's position on the optical target. The target was a 2.3-cm diameter circular target located 5 m away. This simulated a 46-cm diameter target at 100 m, which is similar to the standard 49 cm wide, 100 m military silhouette man.

Participants fired the weapon from two positions: the prone supported position and the free-standing unsupported position. The initial shooting position was randomized across the marksmanship test sessions. Each participant fired 2 sets of five shots in both shooting positions. Participants were instructed to shoot each shot as rapidly as possible in response to a stimulus light without sacrificing accuracy. Participants were given a verbal ready signal and, after a randomly varied 1-to 10-second preparatory interval, were signalled to shoot by the illumination of a red LED light positioned 8 cm to the left of the target. STIME was the time of light illumination to trigger pull. During the prone supported position, participants were instructed to hold the rifle low enough to enable them to see the stimulus light from above the rifle's sights. In the free-standing unsupported position, participants were required to hold the barrel of the rifle below their waist while waiting for the stimulus light to come on.

The volunteers trained with the simulator twice a day on days 1 and 2. During training, participants fired in both shooting positions. Each session consisted of 30 rounds, for a total of 60 rounds per day. During the afternoon training sessions on days 3 and 4, each participant completed the marksmanship protocol used for experimental testing.

Profile of Mood States

The Profile of Mood States (POMS) (McNair et al., 1971) questionnaire was used to identify subjective mood changes. The POMS is a 65-item, adjective rating scale designed to assess six mood states (tension, depression, anger, vigor, fatigue, and confusion). Each adjective was scored from 0 (not at all) to 4 (extremely). The response set of "How you have been feeling during the past few hours" was used in the

instruction description to obtain general mood in response to the various experimental conditions.

Blood Analysis

Blood samples were drawn from a forearm vein during baseline testing, after exercise testing on day 5, and during endpoint testing on day 6. With each venipuncture, 24 ml of blood was removed for analysis (therefore, 72 ml for the study). All samples were collected after the subjects had been sitting quietly with their arm in a supported position for at least 5 min. Samples collected during baseline and endpoint testing were obtained following an overnight fast and were collected the same time of day.

A standard 20-variable blood chemistry profile was performed to assess general nutrition and health status using a Beckman Synchron CX5 automated chemistry analyzer. Hematology measures were measured using Coulter JT Blood Analyzer. Changes in blood and plasma volume were calculated from hemoglobin and hematocrit (Dill and Costill, 1974).

Immune studies examined leukocyte populations, *in vitro* proliferative activity, and interleukin production. Leukocyte populations were determined via flow cytometry after staining and fixation. Blood was prepared for *in vitro* blastogenesis as described by Kramer et al. (1990). Proliferative activity was determined *in vitro* based on DNA incorporation of tritiated thymidine (methyl-3H; New England Nuclear) into cell cultures. Details of blood analysis have been reported in detail (Shippee et al., 1995).

Anthropometry and Body Composition

Body height (pre-measurement only) was measured in stocking feet standing on a flat surface with the top of the head held horizontally. Body weight was measured using a calibrated digital scale accurate to 0.1 kg (Seca).

Initial body composition was measured using DEXA. For the DEXA measurements, subjects were supine and dressed in shorts and t-shirt. The "fast" 10-

minute scanning speed was used for the measurement. The DEXA instrument was packed, moved, unpacked, and calibrated by a manufacturer's representative to ensure proper operation during the study.

Body Fluid and Caloric Balance

Body fluid balance was assessed by changes in body weight, fluid intake, and urine output beginning day 3 and ending after testing on day 5. All urine excreted was collected in ~1 L containers. Fluid intake was estimated by recording the volume of fluid consumed from each soldier's canteen(s). Caloric intake was estimated from dietary records kept by each soldier.

Total Body Water

Total body water was measured during preliminary testing and during endpoint testing using bioelectrical impedance (Xitron Technologies). The procedure was performed after placing spot, paste-on, electrodes on the trunk, wrist and ankle. A 200 μ A current was then passed between the primary electrodes while the secondary electrodes recorded the voltage drop as resistance values. Established formulas were then used to calculate total body water.

STATISTICAL ANALYSIS

Analysis of variance procedures were used to assess whether the beverage solution affected the dependent variables measured. When a significant F ratio was obtained ($P < 0.05$), Dunetts' test or Tukey's HSD test were used for post hoc analysis. Data are presented as means \pm sd.

RESULTS

The CHO-E beverage was well tolerated by the subjects assigned the beverage and comprised 86 \pm 8% of total fluid intake. The subjects in this group liked the beverage when resting, but found it too sweet during exercise. The placebo solution was disliked by many of the subjects. They found it too "acidic" to drink in large

quantities. The placebo beverage comprised $68 \pm 15\%$ of their total fluid intake. One subject, assigned to the placebo group, refused to drink the placebo solution after consuming ~ 2 L during the first road march. His data were re-assigned to the water group for statistical analysis. Therefore, there were ten, seven and ten subjects in the CHO-E, placebo and water groups, respectively.

During the road marches on training days 1 and 2, the WBGT progressively increased from $22\text{--}24^\circ\text{C}$ to 27°C by the end of the march. During the day 3 road march, the initial WBGT (0730 h) was only 18°C , but rose to 31°C by 1100 h. At Mount Yonah campsite (and testing site) the WBGT rose from 20°C to 32°C during testing.

FLUID AND CALORIC BALANCE

Body weight changes and fluid intake results are presented in Table 2. The quantity of carbohydrate and calories ingested during the study are presented in Table 3. Field training induced a $\sim 2\%$ (range 0-4%) body weight loss, with no difference among the groups. Total fluid intake was similar among the groups during field training as the CHO-E, placebo, and water groups drank 14.9 ± 3.7 , 16 ± 2.3 , and 13.9 ± 3.0 L, respectively.

Total urine volume was also similar among groups averaging 3.8 ± 1.9 , 3.9 ± 1.4 , and 4.2 ± 1.5 L, for the CHO-E, placebo, and water groups, respectively. The flavored beverage groups, however, had greater net fluid retention compared to the water group as the difference between fluid intake and urine volume was greater ($P < 0.05$) in the CHO-E and placebo groups than in the water group. The carbohydrate drink increased ($P < 0.05$) both total carbohydrate and total caloric intake. The CHO-E group ate ~ 500 kcal/day less ($P < 0.05$) than the water group, but obtained an additional 1505 ± 294 kcal/day by drinking the beverage.

Table 2. Body weight changes and fluid intake during 3 days of field training.

| | CHO-E | Placebo | Water |
|---------------------------------------|--------------------------------|---------------------------------|--------------------------------|
| Δ Body Weight, kg | -2.1 \pm 1.3 (-4.4- -0.2) | -1.6 \pm 1.2 (-3.39- -0.8) | -2.4 \pm 1.3 (-3.7- -0.2) |
| Total Beverage Intake, L | 13.0 \pm 4.0 (10-22.5) | 10.9 \pm 2.9 (7-16) | |
| Total Fluid Intake, L | 14.9 \pm 3.7 (11-22.5) | 16.0 \pm 2.3 (14-20) | 13.9 \pm 3.0 (9-19.3) |
| Beverage Intake, % of Total Intake | 86 \pm 8 (71-100) | 68 \pm 15 (50-89) | |
| Urine Volume, L | 3.8 \pm 1.9 (1.4-6.5) | 3.9 \pm 1.4 (2.0-6.3) | 4.2 \pm 1.5 (3.4-6.7) |
| Total Fluid Intake- Total Urine, L | 11.1 \pm 2.6 (8.1-16.2) | 12.1 \pm 1.5 (10.2-14.2) | 9.6 \pm 2.6 (5.1-12.6) |

Data are means \pm sd for 10, 7 and 10 subjects in CHO-E, Placebo and Water groups, respectively. Values in parenthesis are the range of values within the group.

Table 3. Caloric and carbohydrate intake during 3 days of field training.

| Variable | CHO-E | Placebo | Water |
|-----------------|-------------------|----------------|-----------------|
| Day 1 Kcal | 3670 \pm 674*† | 2252 \pm 388 | 2541 \pm 487 |
| Day 2 Kcal | 3345 \pm 546*† | 2422 \pm 529 | 2458 \pm 363 |
| Day 3 Kcal | 831 \pm 629*† | 81 \pm 298 | 313 \pm 551 |
| Total Kcalories | 7846 \pm 1460*† | 4755 \pm 973 | 5312 \pm 1228 |
| Day 1 MRE, Kcal | 2039 \pm 290* | 2252 \pm 388 | 2541 \pm 487 |
| Day 2 MRE, Kcal | 1966 \pm 518* | 2422 \pm 529 | 2458 \pm 363 |
| Day 1 CHO, g | 629 \pm 144*† | 251 \pm 56 | 309 \pm 62 |
| Day 2 CHO, g | 578 \pm 121*† | 269 \pm 83 | 300 \pm 51 |
| Day 3 CHO, g | 179 \pm 119*† | 7 \pm 30 | 42 \pm 78 |
| Total CHO, g | 1386 \pm 326*† | 527 \pm 146 | 651 \pm 167 |

Data are mean \pm sd for 10, 7 and 10 subjects in the CHO-E, placebo and water groups, respectively. * Different than water group, $P < 0.05$. † Different than placebo group, $P < 0.05$.

Figure 1 presents the percent change in blood volume and the absolute values for plasma osmolality and lactate concentration during the study. Hemoglobin (Hb) and hematocrit (Hct) were similar among groups throughout the study and, as such, there were no differences in calculated blood volume or plasma volume among groups. Field training increased calculated blood and plasma volumes as recovery values were higher ($P<0.05$) than baseline values. There were no differences among groups for plasma osmolality or lactate concentration. Post-exercise plasma osmolality and lactate concentration were higher ($P<0.05$) compared to baseline values.

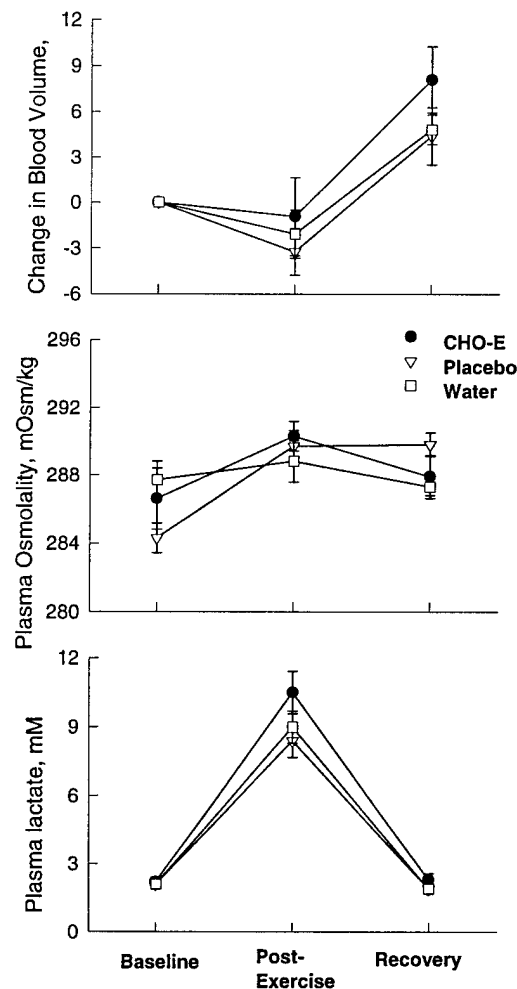


Figure 1. Change in blood volume and absolute values for osmolality and lactate concentration during 3 days of field training.

Figure 2 presents the plasma glucose responses of each group during the study. There were no differences in plasma glucose concentration among the groups either at baseline or in recovery. Post-exercise, plasma glucose was reduced ($P < 0.05$) in the placebo group, compared to the other groups (5.0 ± 0.9 , 4.2 ± 0.6 , and 5.3 ± 1.2 mM for CHO-E, placebo, and water groups, respectively).

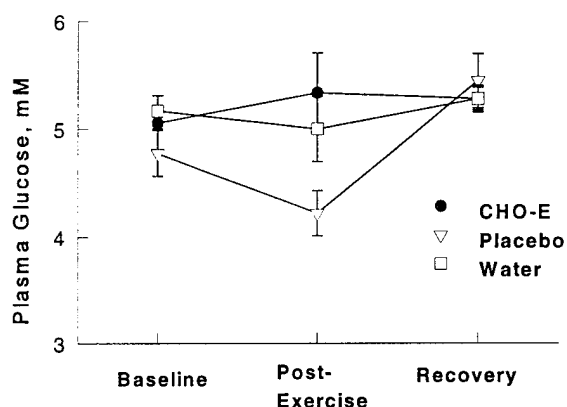


Figure 2. Plasma glucose concentration at baseline, post-exercise and recovery for each treatment group.

ROCK CLIMB AND FOOT RACE

The results of the rock climb and foot race are presented in Table 4. Rock climb ability varied widely among the subjects, with initial climb times ranging from 3.25 to 15.70 min. Field training tended to slow climb time ($P < 0.07$). The CHO-E group tended to climb faster than the other groups, but this difference was not statistically significant ($P < 0.24$). Drinking the CHO-E beverage did not improve rock climb time compared to the other groups, as the change in pre-rock to post-rock climb time was similar among the groups. There appeared to be no trend for the CHO-E beverage to enhance rock climb score when compared to the other groups (Figure 3).

Table 4. Rock climb and foot race time for the three drink groups.

| | CHO-E | Placebo | Water |
|---------------|--------------|--------------|--------------|
| Rock Climb | 5.54±1.88 | 8.11±3.86 | 7.24±3.18 |
| Pre, min | (3.67-8.55) | (4.65-15.70) | (3.25-12.08) |
| Rock Climb | 6.63±2.96 | 9.34±2.96 | 7.38±4.41 |
| Post, min | (3.72-13.0) | (5.63-13.0) | (3.03-17.68) |
| Post-Pre, min | 1.10±1.56 | 1.23±2.34 | 0.14±2.64 |
| | (-0.26-4.87) | (-3.57-3.54) | (-2.07-6.56) |
| % Change | 18±22 | 22±23 | 0±30 |
| | (-7-60) | (-23-41) | (-36-59) |
| Run Time | 6.05±0.80 | 6.62±0.76 | 6.40±0.63 |
| Pre, min | (5.05-7.07) | (5.68-7.60) | (5.53-7.55) |
| Run Time | 6.77±0.75 | 8.07±0.96 | 7.55±1.30 |
| Post, min | (5.75-7.82) | (7.08-9.08) | (6.25-9.80) |
| Post-Pre, min | 0.71±0.33 | 1.45±0.59 | 1.15±1.04 |
| | (-0.04-1.15) | (1.0-2.7) | (-0.23-2.95) |
| % Change | 12±6 | 22±9 | 18±16 |
| | (-1-21) | (14-42) | (-3-43) |

Data are mean±SD for 10, 7 and 10 subjects in the CHO-E, placebo and water group, respectively. Values in parenthesis are the range of values within the group.

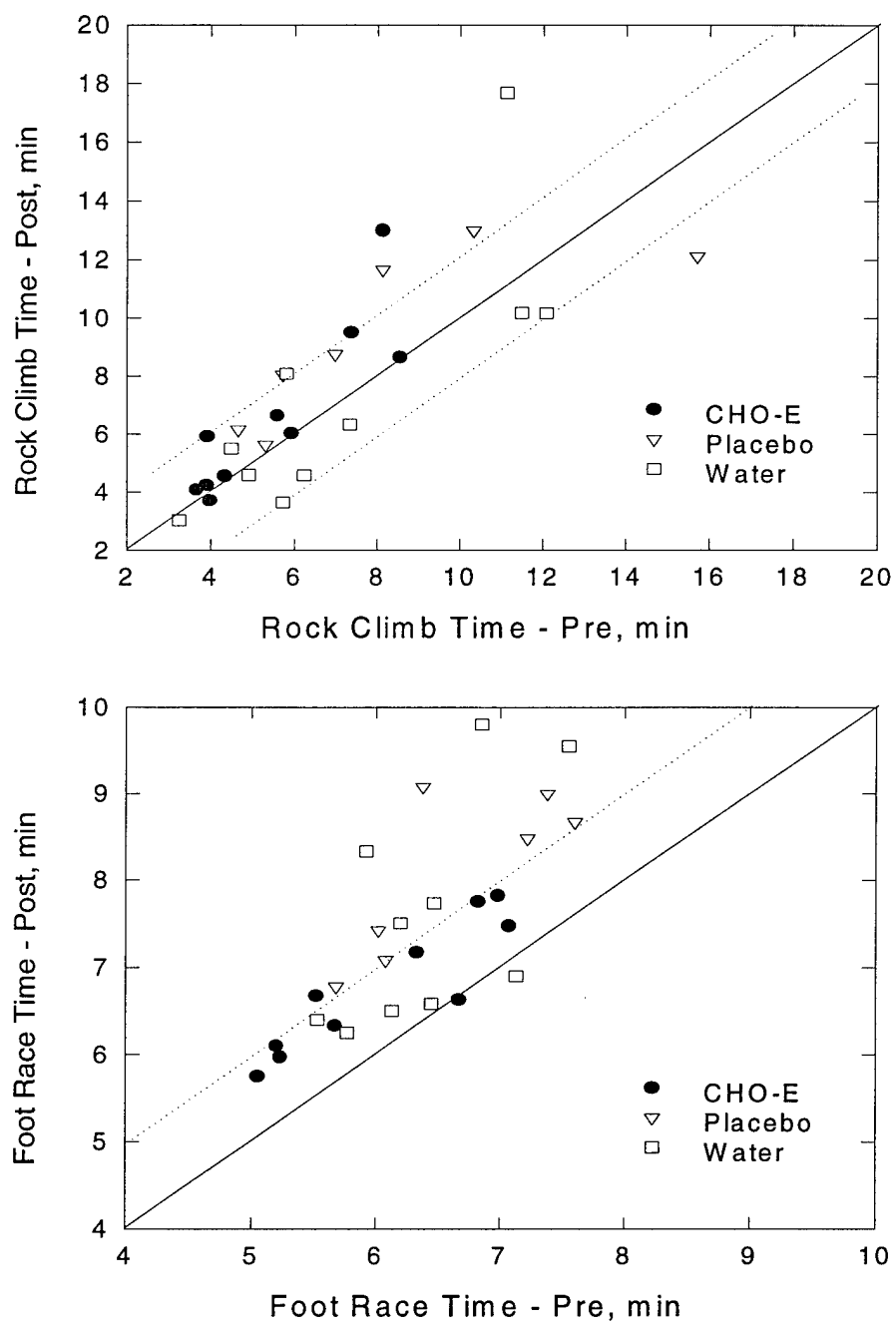


Figure 3. The relationship between pre- and post-training rock climb time (A) and foot race time (B) for the individual subjects.

Pre-training foot race times were similar among groups. Field training slowed foot race time in all groups ($P < 0.05$). The CHO-E group tended to have less decrement in foot race time compared to the other groups, but this did not achieve statistical significance ($P < 0.13$). Power analysis (Cohen, 1969) suggested that at $R = 0.75$, $\alpha < 0.05$ and Power = 0.80, 7 subjects per group was sufficient to assess statistical significance. Figure 3 graphically illustrates the distribution of pre-training to post-training foot race times for the individual subjects. Only one of ten subjects in the CHO-E group slowed more than 1 min after field training, while seven of seven and five of ten subjects in the placebo and water groups, respectively, slowed more than 1 min.

There was a curvilinear relationship (Figure 4) between the decrement in foot race time after training and the quantity of either carbohydrate or calories ingested during the training, with the decrement increasing rapidly when less than 800 g of carbohydrate or 6000 kcal were ingested. Analysis of placebo and water groups alone revealed an inverse correlation for both carbohydrate intake ($r = -0.75$; $P < 0.05$) and total caloric intake ($r = -0.78$; $P < 0.05$) with decrement in foot race time.

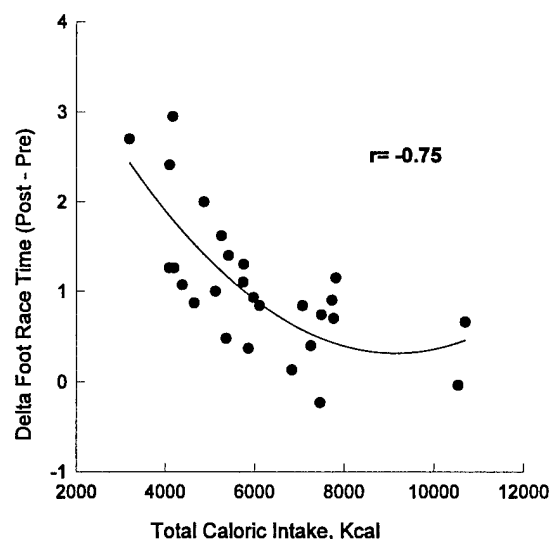


Figure 4. The relationship between decrement in foot race time and total caloric intake during field training.

MARKSMANSHIP

Four practice sessions were insufficient to fully 'train' the subjects on the Noptel simulator. The subjects' test score improved between the baseline measures obtained the morning of day 1 field training and the afternoon of day 2 field training. Secondly, differences in lighting affected marksmanship accuracy. The target was artificially illuminated when shooting in the dark, but the volunteers still shot less accurately when shooting during the pre-dawn hours. Due to the confounding influence(s) of

Figure 5 presents the marksmanship results when shooting in the prone and upright positions. In the prone position, shot group tightness was similar among the groups at all measurement times. Shot group tightness was reduced ($P<0.05$) post-road march, as the water group tended to have a less tight shot group than the other groups. Sighting time was faster ($P<0.05$) post-road march and post-foot race compared to pre-exercise, largely due to shorter sighting times in the placebo and water groups. Distance from centroid of mass increased ($P<0.05$) post-road march compared to pre-exercise measures in all groups, but returned towards baseline during post-foot race testing. Power analysis (Cohen, 1969) suggested that at $\alpha=0.05$, power=0.80 and $R=0.75$, ~7 subjects per group was sufficient to assess differences between CHO-E and water groups for prone SGT, DCM, and sighting time.

In the standing position, there were no differences in shot group tightness among groups. Sighting time tended to be faster ($P<0.13$) post-road march compared to pre-exercise measures, but was not different among the groups. Distance from centroid of mass did not change significantly ($P>0.05$) post-ruck or post-foot race compared to pre-exercise and there was no difference among groups. Power analysis revealed that at $\alpha=0.05$, power=0.80, and $R=0.75$ 45, 500 and 50 subjects were necessary per group to detect differences for SGT, DCM, and sighting time, respectively, between CHO-E and water groups suggesting no real differences between groups for these measures.

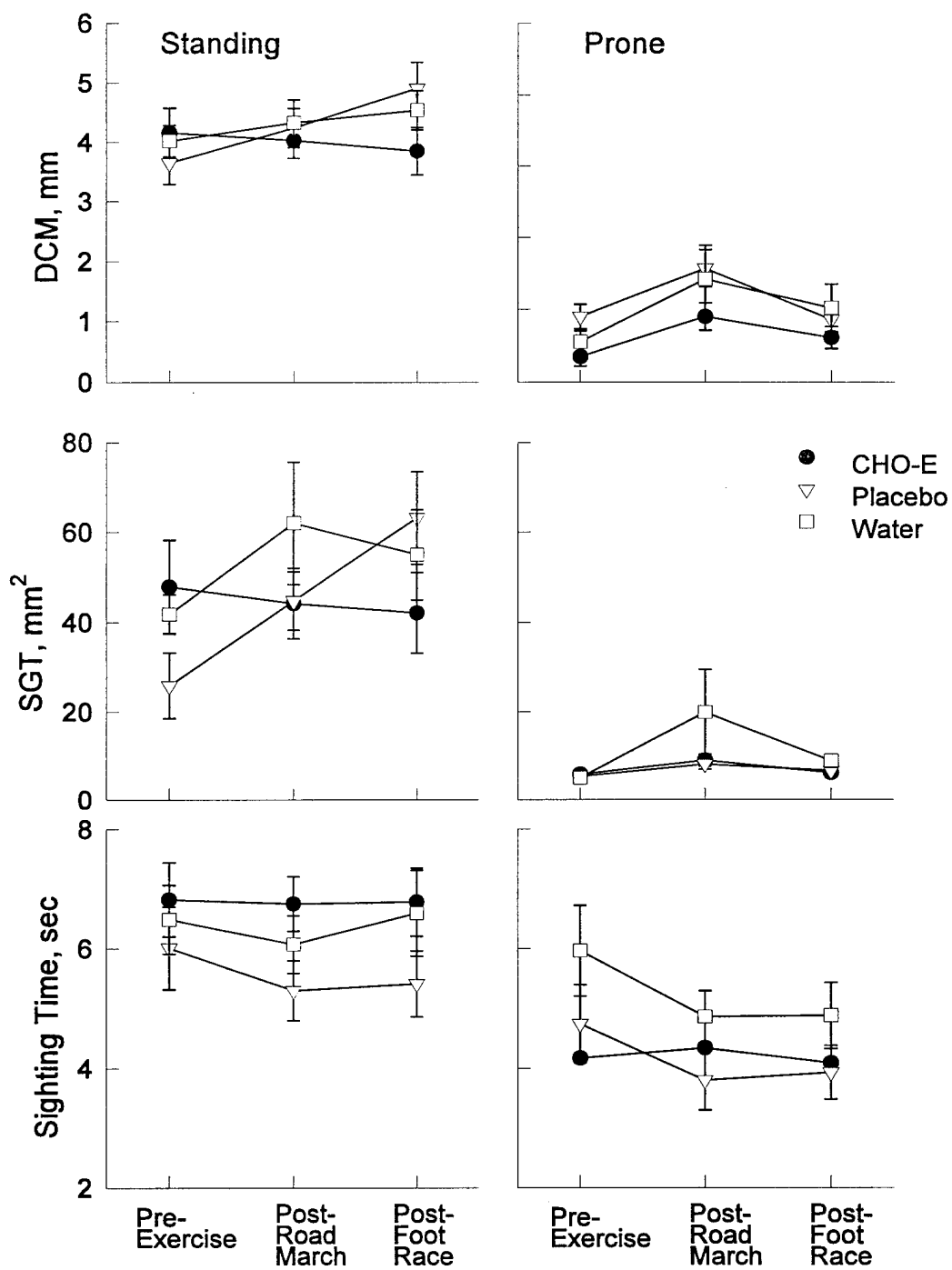


Figure 5. Marksmanship performance during field training for the CHO-E, placebo, and water groups.

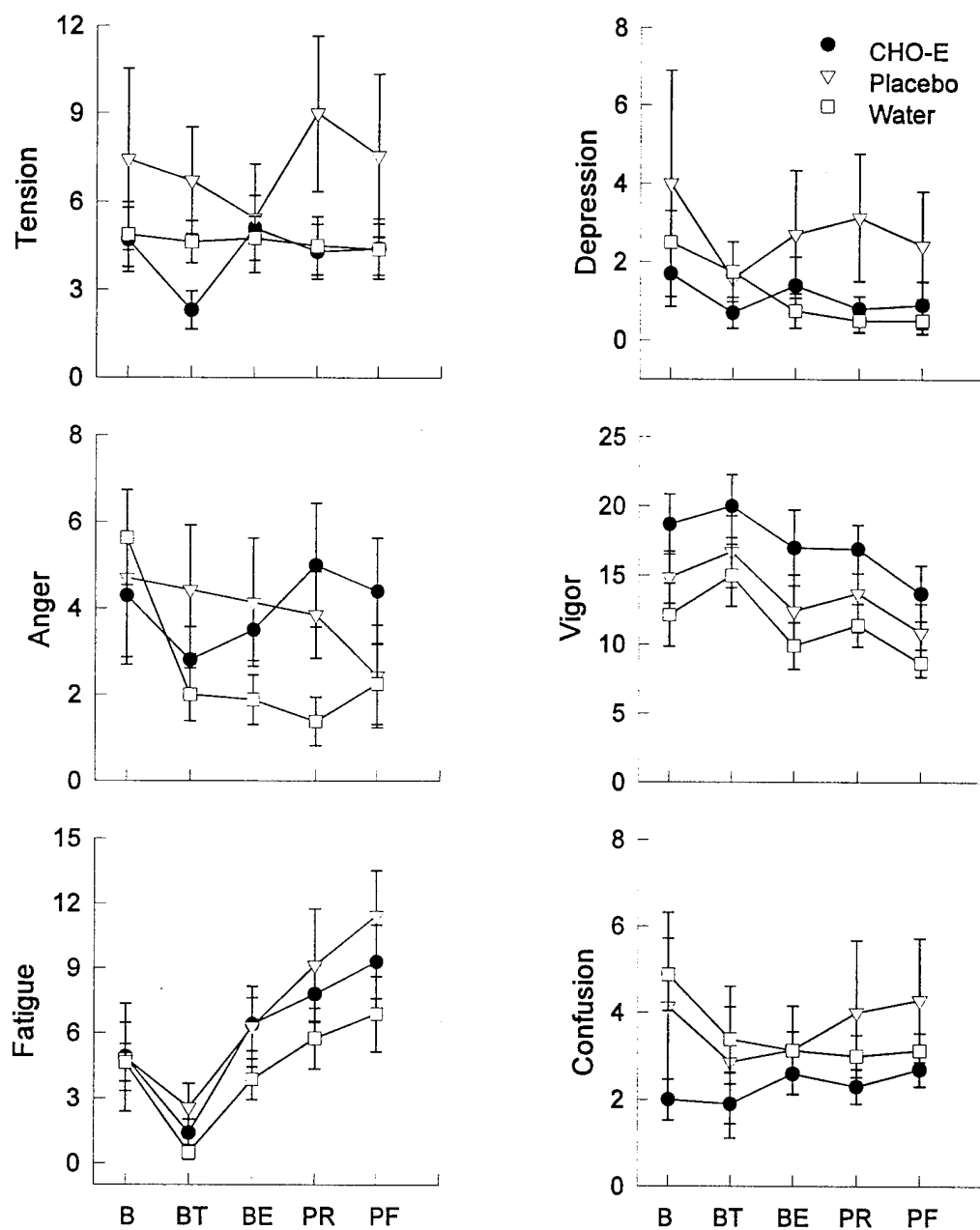


Figure 6. Profile of mood state before and during field training. B, baseline; BT, before training; BE, before exercise day 5; PR, post road march; PF, post foot race.

POMS

Figure 6 presents the individual mood states for each group during the study. Drinking the CHO-E beverage did not significantly affect any of the individual mood states compared to water or the placebo beverage. Vigor was reduced compared to pre-training values ($P<0.05$) prior to day 5 testing and after the foot race. Feelings of fatigue were elevated ($P<0.05$) before and during post-training testing compared to pre-training values. The mood scales of tension, depression, anger, and confusion remained similar to pre-training values during the study. Figure 7 presents the total mood disturbance score for each group during the study. Drinking CHO-E had no affect on total mood disturbance compared to drinking water or placebo beverage.

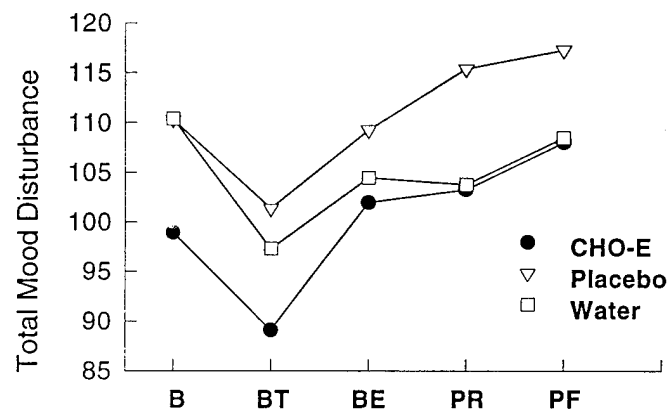


Figure 7. Total mood disturbance during field training. Abbreviations are the same as figure 6.

IMMUNE FUNCTION

Figures 8-10 present the immune cell responses for each group during the study. White blood cell counts were similar between the groups prior to training and the day following field training. White blood cell counts were elevated ($P<0.05$) after exercise in all groups, but rose less ($P<0.05$) with CHO-E than the other beverages. Total

lymphocytes were similar among groups during the study. Exercise produced a 18% increase ($P<0.05$) in total lymphocytes. Monocytes were also similar among the groups during the study. Post-exercise, monocytes were 60% higher ($P<0.05$) than at baseline. Granulocyte count was similar among the groups at baseline and recovery. CHO-E attenuated ($P<0.05$) the exercise-induced rise in granulocyte count. Total T-lymphocyte and T-helper lymphocyte counts were not affected by the beverage or exercise. T-suppressor lymphocytes were elevated after exercise with no statistical difference among the groups, however, there was a trend for the T-suppressor count to rise more with CHO-E than the other beverages. Natural killer cell counts were similar among groups during the study. Exercise produced a 50% increase in natural killer cells. The beverage composition did not affect the magnitude of increase in natural killer cells with exercise. B lymphocyte cells were not affected by exercise or drink composition. Lymphocyte proliferation was similar among groups at baseline. Post-exercise, the proliferation response was reduced by 24%, 31% and 57% compared to baseline for CHO-E, water, and placebo, respectively. The post-exercise proliferation index was lower ($P<0.05$) for placebo compared to the other groups. The day following training, the proliferation index was similar among groups, but remained 28% lower than at baseline.

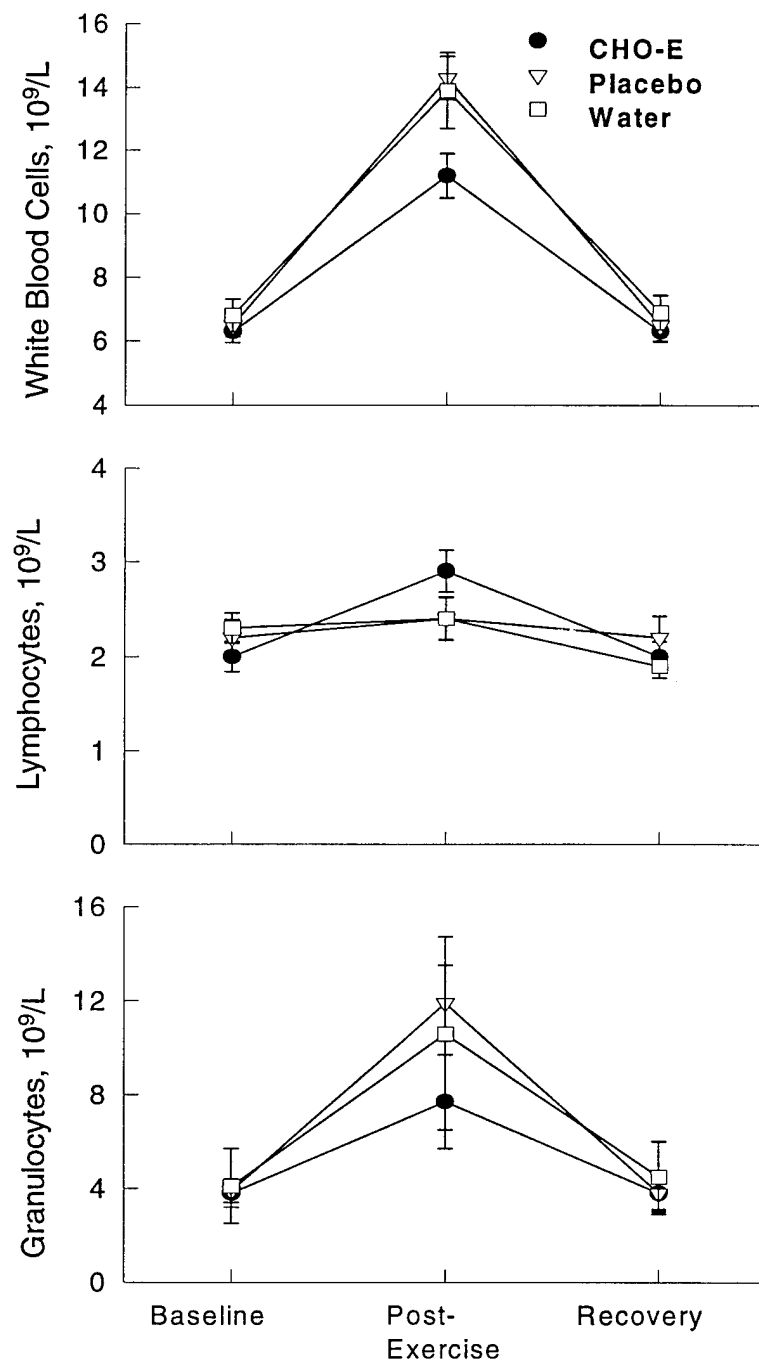


Figure 8. Monocyte, lymphocyte, and granulocyte concentration at baseline, post-exercise and the day following field training.

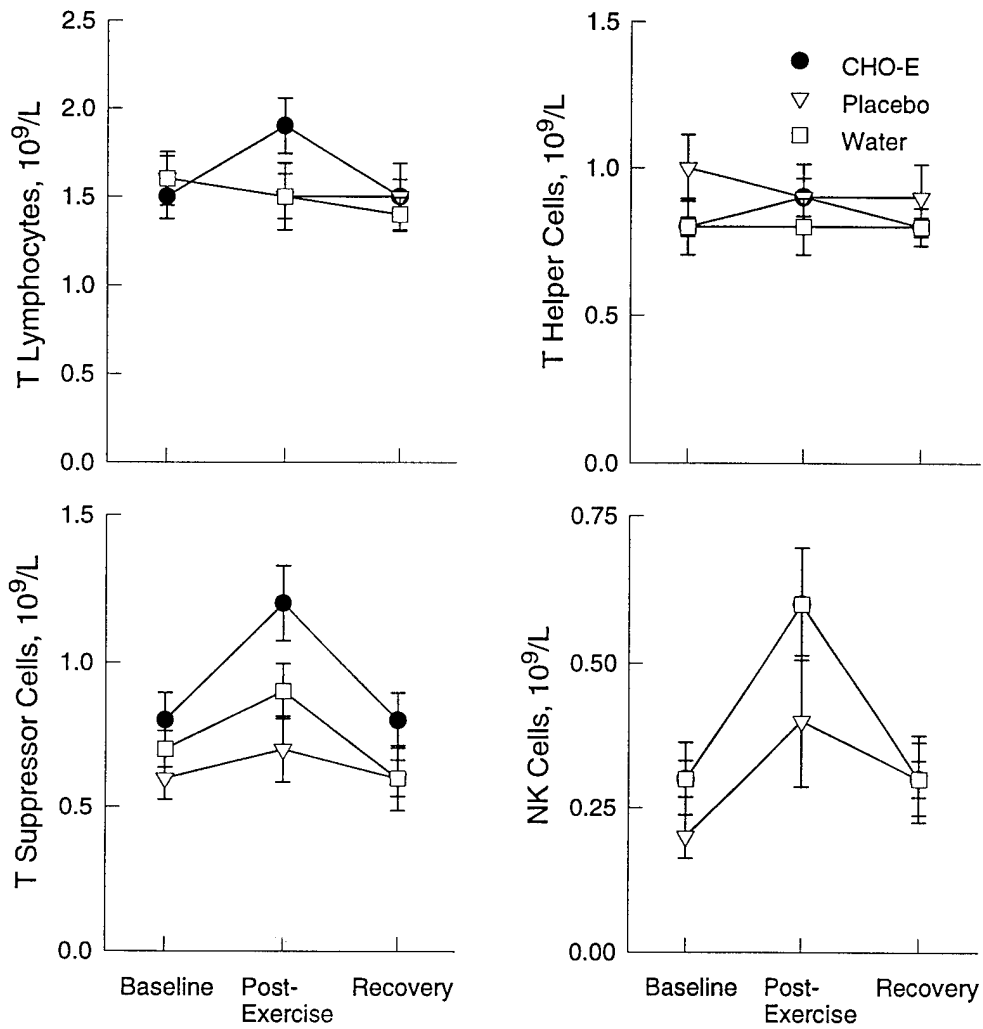


Figure 9. T-lymphocyte concentrations at baseline, post-exercise and the day following field training.

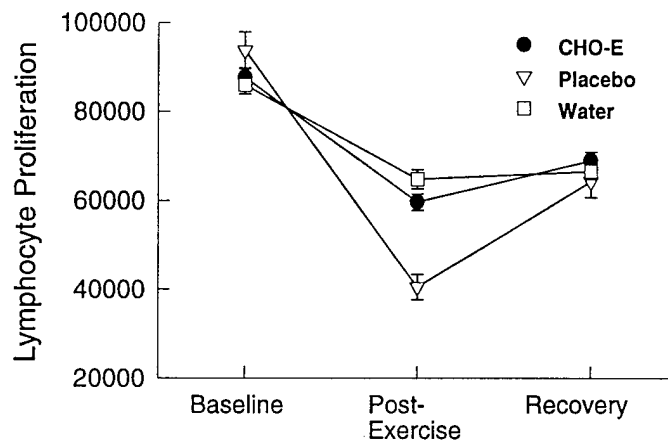


Figure 10. Lymphocyte proliferation index at baseline, post-exercise, and the day following field training.

DISCUSSION

This study examined whether CHO-E beverages improve physical performance of military tasks. In addition, we evaluated whether CHO-E beverages alter immune responses of soldiers during short-term field training. It was hypothesized that CHO-E beverages would have their greatest potential impact during prolonged strenuous exercise requiring large quantities of fluid and foodstuffs to maintain fluid and caloric balance. As such, we examined the impact of drinking CHO-E beverages as the primary fluid replacement solution during 3 days of strenuous field training. Rock climb time, foot race time and marksmanship ability were examined before, during, and after training to assess performance of military relevant tasks.

Studies have reported that CHO-E beverages increase fluid intake when no food is ingested (Hubbard et al., 1984; Rolls, 1986; Sohar et al., 1962). We found no difference in either the total fluid intake or the change in body weight among the CHO-E, placebo, and water groups after 3 days of field training. Therefore, flavoring the

beverage did not significantly increase fluid intake or alter hydration status over 3 days of training. Our results are similar to those of Burstein et al. (1994) who reported similar total fluid intake over several days of marching regardless whether soldiers drank CHO-E or water. It is likely that the beneficial effects of flavoring on voluntary fluid intake (Hubbard et al., 1984; Rolls, 1986; Sohar et al., 1962; Rose et al., 1989) were lost when the thirst mechanisms were activated during and following meals. Adolph and associates (1947) found that fluid intake is greatest at mealtime, and that persons are able to fully rehydrated over a 24-h period when provided meals. In this study, two field rations (meal ready to eat) were provided per day.

An interesting observation was that CHO-E appeared to reduce food intake. The soldiers receiving the drink ingested 2500-3100 kcal more than the other groups during the study. The extra calories came exclusively from the beverage as the CHO-E group ate 300-500 kcal/day less than the other groups. This compensatory reduction in food intake could compromise vitamin and nutrient status if the dietary intervention was continued for extended periods.

PHYSICAL PERFORMANCE AND MOOD

This study found that CHO-E beverages were of no benefit for sustaining physical performance of military relevant tasks. Drinking CHO-E during three days of military training did not improve foot race, marksmanship or rock climb performance compared to drinking a non-caloric flavored beverage or water. The results of this study, therefore, suggest that supplementation of MRE rations with CHO-E beverages is not beneficial for physical performance.

We found that foot race time was not improved by CHO-E despite ingesting an additional 250-300g of CHO/day during the 2 days of field training and 140-170 g CHO prior to the footrace. This is in contrast to several laboratory studies demonstrating that endurance-trained athletes have an improved ability to sprint (similar to our foot race test) after several hours of endurance exercise when consuming carbohydrate (Neufer et al., 1987; Williams et al., 1990; Mitchell et al., 1989). The disparate results are likely due to differences in experimental design. The energy expenditure required to complete the road march was likely less than earlier studies, and presumably, required

less reliance on carbohydrate for energy. If our experimental conditions had depleted endogenous carbohydrate stores, CHO-E beverages probably would have improved foot race performance. However, this is an unlikely military scenario as food stuffs would provide an exogenous source of CHO and serve the same role as CHO-E beverages.

The individual data suggest that CHO-E beverages can attenuate the decline in physical performance during field training. Only 10% of the soldiers in the CHO-E group slowed by greater than 1 min, while 50 and 100% of the soldiers in the water and placebo groups, respectively, slowed by more than 1 min after field training. The trend, however, can be explained by the caloric and/or carbohydrate intake of the water and placebo groups. There was a curvilinear relationship between the decrement in run time after training and the quantity of calories (and carbohydrate) ingested during training by these groups. CHO-E supplementation was not necessary if sufficient calories were ingested during the training period since soldiers in the water group who ate the food provided were able to maintain run performance better than those who ate only a portion of their rations. These findings suggest that attention to food discipline is important during field training and that CHO-E beverages can be beneficial for maintenance of physical performance when limited food is available.

The rock climb test was included to provide a test that required physical strength, endurance and coordination. Unfortunately, despite choosing a military population working at the US Army Ranger Mountain Training Center, Camp Merrill, GA, individual rock climb skills appeared to be improving during the study. As such, the test lacked sensitivity for evaluating the benefits of CHO-E beverages on performance as differences between the treatment groups may have been masked by the confounding effects of improved rock climbing ability.

Drinking the CHO-E beverage did not provide any additional benefit over water with respect to shooting after 3 days of field training. Sighting time in the prone position tended to be faster ($p < 0.21$) when consuming the CHO-E compared to either the water or the placebo. This was, however, the only trend that existed with respect to type of beverage consumed. Acute exercise reduced shooting accuracy and shortened sighting time in the prone position. These latter findings agree with earlier studies

which found that upright shooting accuracy deteriorated after road marching (Knapik et al., 1991), carrying a rucksack (Tharion and Moore, 1993), carrying patient litters (Tharion et al., 1993), and ascending to high altitude (Tharion et al., 1992). These studies also reported that individuals typically sighted the weapon faster and shot less accurately when fatigued. The current study was unable to detect differences in the standing position, presumably because insufficient training was provided to reduce inter-individual variability in marksmanship.

The mood data also revealed no differences between beverages. Persons drinking CHO-E had similar decrements in vigor and elevations of fatigue as the other groups. Therefore, increasing carbohydrate (CHO) intake over 3 days of training does not appear to affect mood state. Keith et al. (1993) reported that females consuming a low CHO diet during cycle training had less self reported vigor than when consuming normal CHO diet. In contrast, Morgan (1988) found no effect of dietary CHO on exercise mood state. The findings of this study suggest that CHO supplementation with CHO-E drinks has little effect on mood state.

IMMUNE FUNCTION

The effect of exhaustive exercise on the immune system has been the subject of increasing research interest and the topic of several recent review papers (Cannon, 1993; Morgan et al., 1990; Keast et al., 1988; Newsholme et al., 1991; Stone et al., 1991). Physical fatigue may contribute to increased susceptibility to illness. Some athletes appear to suffer high rates of certain illnesses, such as infectious mononucleosis (Foster et al., 1982) and upper respiratory illness (Berglund & Hemmingsson, 1990). Overtraining has been reported to increase incidence of illness (Mackinnon, 1992). Soldiers generally perform less strenuous aerobic exercise than athletes, but mission and tactical scenarios often impose stressors which suppress immune function. Insufficient caloric intake during military operations has been a recurrent finding in field studies conducted by the Military Nutrition Division. Sleep deprivation quite often is either overt during military training or imposed by the tactical scenario. In addition, soldiers often suffer from cuts and bruises due to minor injuries or abrasions, offering ample access for opportunistic infection.

Research studies involving two of the US Army's most physically demanding schools, Ranger and the Special Forces Assessment School (SFAS), have examined the nutritional state, fatigue, and immunocompetence of soldiers during strenuous activity. Persons participating in either course develop signs of immunosuppression. During the 8 week Ranger Training course, circulating levels of the cytokine, IL-6, declined and lymphocyte proliferation to *in vitro* mitogen stimulation was reduced (Moore et al., 1992; Shippee et al., 1995). Similarly, two studies with the SFAS (Shippee et al., 1995; Fairbrother et al., in press) have shown that soldiers completing the 21-day SFAS course have, on average, a 23% suppression of *in vitro* lymphocyte proliferation. The mechanism(s) responsible for the immunosuppression remain unclear; however, both courses include several stressors (i.e., exercise, undernutrition, sleep deprivation, and psychological stress) which can independently compromise immune function (Bondestam et al., 1988; Cannon, 1993; Dorian et al., 1982; Jemmott et al., 1983; Keusch, 1984; Palmblad et al., 1979, Scrimshaw et al., 1968).

The present study provided the opportunity to assess immunological competence over a shorter time period, and to assess the short term impact of dietary intervention. Shippee et al. (1995) demonstrated that a 16% increase in total calories attenuated immune suppression during Ranger Training. No study, however, had evaluated whether dietary modification with a CHO-E beverage altered immune responses over several days of strenuous training.

This study found that exhaustive exercise performed during military related training produced predictable immune responses. Similar to other studies, exercise produced a transient leukocytosis, an increase in granulocyte:lymphocyte ratio, and increased natural killer cell number (Edwards et al., 1984; Mackinnon, 1992; Nieman, 1994; Pedersen et al., 1988). These effects are most likely due to margination of white cells. Mechanical factors, such as increased cardiac output and perfusion of the microvasculature as well as changes in the interactions between leukocytes and endothelial cells of the capillaries, may be involved (Mackinnon, 1992). The trend for a smaller increase in total white cells and granulocytes shown by the CHO-E group is difficult to explain under the current study design.

Exercise produced a 24-57% reduction in lymphocyte proliferation which

remained below pre-training values following 20-24 h recovery. Suppressed lymphocyte proliferation immediately after exercise has been reported by others (Eskola et al., 1978; Gmunder et al., 1988). The effect is usually considered transitory, however, with normal responsiveness being restored 2 h after exercise (Mackinnon, 1992). The reasons for the prolonged suppression are not clear. Differences in lymphocyte subsets do not appear responsible, as NK cell and T cell number were similar pre- and post-training. It is possible that the persistent effects of sleep deprivation and physical fatigue were contributing factors.

The suppressed proliferative response of the Aspartame sweetened placebo group relative to the other two groups is of interest. We are not familiar with literature describing the effects of Aspartame (placebo drink) on the immune system. Because Aspartame contains L-phenylalanine, most research efforts have examined whether Aspartame ingestion affects the health of persons with phenylketonuria. The World Health Organization has set the acceptable daily intake (ADI) of Aspartame at 2.8 g/day for a 70 kg individual (Harriett et al., 1991). This is equivalent to drinking about fifteen 12-oz cans of diet cola. The average intake of Aspartame by the placebo group in the present study was approximately 530 mg/day or about 19% of the ADI.

SUMMARY

This study provides the following new information regarding CHO-E beverages during several day of physical exercise in the heat: 1) Drinking CHO-E rather than water provided no advantage for sustaining or improving physical performance, marksmanship or mood; 2) CHO-E may reduce food intake which can have implications for vitamin and nutrient balance; 3) CHO-E did not enhance hydration status; and 4) CHO-E beverages did not alter immune responses, but data suggest that aspartame drinks may suppress T-lymphocyte proliferation. It was concluded that drinking CHO-E beverages during 3 days of high intensity military training does not attenuate reductions in physical performance.

RECOMMENDATIONS

This study found no beneficial effects of providing carbohydrate-electrolyte solutions with the MRE meal ration; provided sufficient calories and carbohydrate were consumed during training. During several days of field training, therefore, food discipline should be enforced. Soldiers should be encouraged to eat the rations provided. When adequate food cannot be provided, carbohydrate-electrolyte solutions provide a assessible means of supplementing carbohydrate and caloric intake.

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